Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE MORPHOLOGICAL BASIS OF SOME EXPERIMENTAL WORK WITH MAIZE

Of all the plants that have been made to contribute to our knowledge of the principles of evolution and heredity in the last twenty years, probably none holds a more conspicuous place than Indian corn. The technique of its manipulation is comparatively simple, and it exhibits an extreme variability, which is almost unique in extending to the endosperm; the behavior of a large number of its characteristics has been found amenable to a Mendelian interpretation and has aided materially in establishing present-day views of heredity. Indeed, maize shares with *Pisum* the distinction of having been the means of the establishing of Mendelism itself, for it was in connection with their work on maize that Correns and De Vries discovered Mendel's paper. Since then its genetic behavior has been studied in detail by a number of investigators, and there is probably no other one plant that furnishes such a wealth of material illustrative of the principles of heredity.

The writer has in recent years had the opportunity of examining in more or less detail this same plant from the morphological point of view, and it has been found that we are far more familiar with the Mendelian behavior of some of its characteristics than we are with the characteristics themselves. This has led to some results illustrative of the need of very close coordination between genetics and morphology.

In one of the numerous experiments made by East and Hayes, an attempt was made to interpret the Mendelian behavior of the irregularity of the rows of grains on the ear of corn. The ratios produced in the breeding experiments[1] were not very significant, and, after suggesting the possibility of "monohybridism with reversed dominance," "fluctuating dominance," etc., they finally conclude that "it seems probable that a more complex set of conditions exists."

If, as is suggested, this irregularity is similar to that in Country Gentleman sweet corn, it was probably another set of conditions that caused the trouble. As the writer has since pointed out,[2] the irregularity in the rows of this variety is the more or less complete expression of a very definite and comparatively simple state of affairs. Each female spikelet of ordinary maize produces one grain; but in Country Gentleman sweet corn, a second flower, ordinarily aborted, becomes functional, and the spikelet produces two grains. Since there is little or no compensation for this in the length of the cob, and insufficient difference in the size and shape of the grain, the ear is producing a larger volume of embryo and endosperm than is ordinarily produced in the same space. As a result of this crowded condition, the straight rows are more or less obliterated for a more economical arrangement. At times, however, a set of conditions, presumably environmental, may limit the size of the grain or increase the length of the cob sufficiently that the rows are almost straight, although each spikelet is still producing two grains. The genetic experiment, then, was probably dealing with an indefinite expression of a definite characteristic. If the heredity of the two-flowered condition of the spikelet had been tested, a more direct explanation would probably have been afforded.

---

[1] "Inheritance in Maize," Bull. Conn. Agr. Expt. Sta., 167, 1911, p. 132.

[2] "The Morphology of the Flowers of *Zea Mays*," *Bull. Torrey Club*, 43: 127–144, 1916.

Again (p. 134), these same authorities explain the occurrence of hermaphrodite flowers upon the basis that "the immature sex organs, so-called, of maize seem endowed with the power of becoming either stamens or carpels." In so far as actual genetic results are concerned, this is, in most cases, at least, a sound working basis, but it is far from exact morphologically. There is no organ in the young maize flower that has the possibility of becoming in some cases a stamen and in others a pistil. The young flower has the ability to become either staminate or pistillate because it contains primordia of both stamens and a pistil, one or the other of which usually does not develop to maturity.[3]

Blaringhem's extensive experiments,[4] in which he attempts to initiate mutation by means of injuries to the plant, fail to take into full account certain very significant facts of morphology. It is probably for this reason that he believes that the acquisition of hermaphrodite flowers in the maize plant is a *progressive* step. On the contrary, every indication points to the fact that the rudimentary stamens and pistils that have been found in the flowers of maize are the vestiges of organs that have been, and not the phylogenetic forerunners of organs that are to be. Moreover, normal behavior shows that in mutilating the plants he had merely promoted the production of suckers, which normally tend to have bisexual inflorescences. Blaringhem's method is ingenious and would, no doubt, give good results in a study of physiology of monoecism; but, the normal plant being understood, and full allowance being made for the recognized effects of inbreeding, it is not believed that there is any clear evidence that he produced a single *new* hereditary characteristic in maize.

---

[3] *Ibid.*, pp. 129–134.

[4] Blaringhem, L., "Mutation et traumatismes," Paris, 1908.

But not all of the assumptions of fundamentals upon which geneticists have based their work on maize have been so unhappily chosen as those cited. Most of the work that has been done on the heredity of endosperm characters depends upon the so-called "double fecundation" and upon the degeneracy of three of the four potential megaspores. The former of these facts was observed by Guignard[5] in 1901, but he did not figure it; the latter has been deduced by analogy. Circumstantial evidence was good in both cases, but evidence of this kind is not always dependable. No one would risk much in a financial way on chances like these, but some geneticists have risked years of work. In a recent paper[6] the writer has verified the facts assumed in this work.

The peculiar behavior of reciprocal crosses between varieties of corn differing in the physical nature of the starchy endosperm, has been explained[7] by the assumption that the two hereditary factors presumably carried by the two polar nuclei be dominant to the one factor carried by the sperm entering into the constitution of the primary endosperm nucleus. This idea is in accord with the multiple factor hypothesis, and the phenomenon is one of the few *direct* evidences that we have as to the behavior of a double application of a factor as opposed to a single application of its allelomorph. But so little is known of the morphology and the chemistry of these two kinds of starch and their relation to the surrounding tissues that it is not at all improbable that the explanation advanced may be modified by the results of further investigation.

An interesting light is thrown upon the the multiple factor theory by certain other morphological peculiarities of the grain of corn. The essential idea of the multiple factor hypothesis, in a simple form, is that a single visible effect may be due to two or more factors, only one of which is necessary to produce the same effect, at least in a limited degree. Little is known of the relative natures of the two or more factors that compose the multiple unit in the cases that have been investigated; they may be alike, or they may be very different from each other. A grain of corn homozygous for yellow starch and red aleurone is different in color from one having only one of these characteristics. But to a person with defective vision, or when viewed in a light of proper color, these two colors and a combination of the two may appear to be merely different shades of one color. By breeding this stock with a homozygous white, carrying no conflicting factors, we should get what would be to this same defective vision a perfect illustration of the behavior of multiple factors. But it is in reality a case of dihybridism in which we have failed to distinguish between the two sets of allelomorphs. And who can doubt that relatively as great a lack of discrimination may characterize our chemical, physical, or morphological vision in observing some of the classical illustrations to which the multiple factor hypothesis is applicable?

---

[5] Guignard, L., "La double fécondation dans le Maïs," *Jour. de Bot.*, 15: 37–50, 1901.

[6] "Gametogenesis and Fecundation as the Basis of Xenia and Heredity in the Endosperm of *Zea Mays*," *Bull. Torrey Club*, 46: 73–90, 1919.

[7] Hayes, H. K., and East, E. M., "Further Experiments on Inheritance in Maize," Bull. Conn. Agr. Expt. Sta., 188, pp. 12–13, 1915.

Other examples could be selected from the work that has been done on maize, and doubtless many are available from the investigations made with other plants and with animals, but these will suffice for illustration. Many of the organisms most useful for establishing and testing principles of heredity have an external appearance that may be very deceptive as an indicator of their true structure, and the true structure alone is the key to the deeper significance of their genetic behavior.

PAUL WEATHERWAX

INDIANA UNIVERSITY

ON HETEROPHYLLY IN WATER PLANTS

THE occurrence of two or more different types of leaf upon one individual, which is so frequently characteristic of water plants, has long attracted the interest of botanists. The most usual case is that in which the submerged leaves are finely divided while the floating or aerial leaves are relatively simple. Lyte's Herbal (1578) contains a vivid description of this type of heterophylly in the water buttercup. Since this description is also noteworthy for its insistence on the influence of external conditions, it may be cited here.

> Amongst the fleeting [floating] herbes, there is also a certayne herbe whiche some call water Lyverworte, at the rootes whereof hang very many hearie strings like rootes, the which doth oftentimes change his uppermost leaves according to the places where as it groweth. That whiche groweth within the water, carrieth, upon slender stalkes, his leaves very small cut, much like the leaves of the common Cammomill,